

0.28 inch, or 0.64 below normal. The rainfall here since January 1 totals only 8.53 inches, 6.97 inches below normal.

Few disturbances of importance occurred during the month. The first to be reported was a small one off the Mexican coast, south of the Gulf of Tehuantepec, which was felt on the 3d to 6th by vessels on the California-Panama route. Its cyclonic character and small size are indicated by the reports of the steamships *Margaret Coughlan* and *W. H. Tilford*, which were in close proximity on the morning of the 5th, southward bound. At 5.40 a. m. (L. M. T.) the former was in $14^{\circ} 10' N.$, $94^{\circ} 50' W.$, the latter in $14^{\circ} 15' N.$, $95^{\circ} 00' W.$ At this hour the *Margaret Coughlan* had a north-northeast wind, force 8; barometer, 29.52. The *W. H. Tilford* had a west wind, force 9; barometer, 29.57. Data for this disturbance are too meager to permit of plotting a path or determining the rate of movement. It is evident, however, from the report of a third vessel, the S. S. *Walter A. Luckenbach*, that the center did not move far between the 3d and 5th. This vessel passed over the same route, also southward bound, two days earlier than the vessels previously mentioned and experienced in the same vicinity overcast, squally weather and rough seas. At 4 p. m. of the 3d the barometer had fallen to 29.53, wind east, 7. This was near $13^{\circ} 30' N.$, $94^{\circ} 30' W.$ Later the wind veered to SE., continuing from that direction until the morning of the 4th, when it went to S. and SSW., diminishing to force 3.

From the 7th to 9th vessels in the western part of the ocean experienced moderate to fresh southerly and westerly gales, associated with a depression which was then advancing toward the Aleutians and which contributed to the low pressure already mentioned as obtaining in midocean on the 9th to 11th.

On the 27th to 29th vessels east of Japan experienced moderate to strong gales, which seem to have been occasioned by a disturbance that was over northern Japan on the 27th and 28th, and which moved thence in a north-easterly direction. At 8 p. m. on the 29th the barometer on board the S. S. *President Grant*, in $43^{\circ} 17' N.$, $155^{\circ} 10' E.$, fell to 28.85 inches. The highest force of wind experienced by this vessel was 9 (SW.).

The S. S. *President Pierce* was involved to some extent in this disturbance. Mr. J. B. Zimmerman, third officer and observer, states that it occasioned an unusual sky display on the 27th. The following is taken from his report:

As the sky cleared in the afternoon a magnificent display of clouds came to view. Sky was bright blue to deep blue overhead. Close to the surface raced detached patches of cumulus clouds from NW. to SE. Above them, SSE. to NNW., traveled another set of broken shreds of clouds, and high aloft, slowly converging from NNW. to a point of the horizon bearing SSE. streamed cirrocumulus and cirrus clouds. At sunset the sight was beyond description. A rosy sunset with all the colors imaginable and the most perfect forms of cirrus clouds I have ever seen.

Other gales reported as occurring at various times during the month are recorded in the accompanying table.

DETAILS OF THE WEATHER IN THE UNITED STATES

GENERAL CONDITIONS

"Warm and dry" best characterizes the weather of the month, the important exception being in the Missouri and upper Mississippi valleys and New England where the precipitation was greater than normal. An unusual, for June, hot spell persisted in central and eastern districts during the first 10 days of the month.—A. J. H.

CYCLONES AND ANTICYCLONES

By W. P. DAY

Low-pressure areas were about normal in number. Several of the more important storms developed over the southern Rocky Mountain region or the Southern Slope, although the associated katabatic winds were sometimes first noted on the Pacific coast.

The high-pressure areas were about normal in number, and about equally divided between the so-called Alberta and North Pacific types. The high of the 9th-12th, which brought an end to the warm wave of the first decade, was apparently built up behind the preceding low merely by the inrush of the cooler and hence denser air near the surface in its rear, and on this account was quite shallow as indicated by airplane observations of temperature secured at Washington on the morning of the 11th. There was a decided lapse in temperature up to about 1,200 meters as compared with the preceding day; but above this elevation a strong inversion existed with no change in temperature. It is also interesting to note that this shallow wedge of cold air underrunning warmer air aloft was not accompanied by precipitation within a radius of more than 200 miles of Washington. Thus the real break in the heat wave over a wide territory came with fair weather.

FREE-AIR SUMMARY

By V. E. JAKL

Table 1 shows a well-marked positive departure in temperature at Broken Arrow, Due West, and Groesbeck, and a similarly well marked negative departure at Ellendale. At Broken Arrow, Due West, and Ellendale the departures diminished with altitude, indicating that the contrast in temperature between the northern and the southern stations was, to a larger degree than normal for the month, greater in the lower levels than in the upper. Table 2 shows that at Ellendale the winds up to about 2,000 meters had a northwesterly component instead of the southwesterly directions normal for the month. Otherwise there were no important free-air departures in the various averages for the aerological stations.

The departures in temperature and wind at Ellendale are significant in connection with the unusual amount of precipitation at that station. In order to emphasize the distinguishing feature of the free-air conditions in their bearing on this precipitation comparison will be made with the aerological record at Due West, where the precipitation was distinctly deficient. The comparison supports a conclusion brought out in last month's (May, 1925) free-air summary, viz, that in so far as temperatures within the usually observed range of altitude are concerned high lapse rates are not necessarily the precursors of precipitation; also that when lapse rates equaling the dry adiabatic occur they are by no means always productive of heavy or even measurable amounts of precipitation.

Note should be made of the average lapse rate at Ellendale and Due West in Table 1, where, from 500 meters to 3,500 meters, Due West has a rate of 0.73° , and Ellendale, 0.52° . From individual observations and

the record of surface temperatures it is apparent that at Due West a lapse rate equaling or closely approaching the dry adiabatic, and extending to probably 3,000 meters, was undoubtedly effected in the majority of the afternoons during the month. As might be expected from such an unstable condition, thunderstorms occurred at Due West on 15 days, with a trace or more of rainfall on 16 days, but the total precipitation for the month was only 1.73 inches, or less than half the normal amount. At Ellendale, however, as a result of 12 thunderstorms and 13 days with measurable rain, a total of 11.81 inches was recorded, or about three times the normal amount.

In looking for a cause for these contrasting conditions at the two stations it appears that Due West was largely under the influence of high or moderate pressure, so that most of the showers were of a local convectional nature and were, furthermore, incapable of causing much precipitation, notwithstanding the high lapse rate, owing to lack of circulation from sources of moisture. On the other hand, Ellendale is found to have been dominated by a succession of troughs of low pressure that extended southward well toward the Gulf, alternating with, or affecting Ellendale in connection with, cool highs that moved along the northern border. The latitudinal contrast in surface temperature over the territory contiguous to Ellendale (Chart III, this REVIEW) and in the free-air (Table 1), shows that Ellendale was frequently in a position favorable for severe thunderstorms of wind-shift line and other cyclonic types.

The following record taken from the observations at Ellendale on the 23d and Due West on the 24th have been selected to illustrate the widely divergent vertical air structure typical of the month at the two stations. The Ellendale observation, which shows a variable lapse rate, averaging 0.47° per 100 meters from the ground to the highest level, can be taken as closely representing the conditions during the prevalence of rain, inasmuch as the observation was overtaken by a storm, during which 0.84 inch rainfall occurred; while at Due West on the 24th, where the observation shows a lapse rate averaging about the dry adiabatic and incipient condensation in the uppermost levels, the conditions were not productive of rain until about four hours later, when only a trace fell.

Altitude m. s. l. (meters)	Due West, S. C. Altitude, 217 meters. June 24, 1925				Ellendale, N. Dak. Altitude, 444 meters. June 23, 1925			
	Tem- pera- ture	Δt 100 m.	Rela- tive humid- ity	Wind direc- tion	Tem- pera- ture	Δt 100 m.	Rela- tive humid- ity	Wind direc- tion
	$^{\circ}C$		Per cent		$^{\circ}C$		Per cent	
Surface.....	36.0		32	W.	16.0		90	E.N.E.
500.....	32.2		31	W.	15.4	1.10	87	E.
1,000.....	26.2		38	W.	17.1	-0.34	55	S.E.
1,500.....	20.8		47	W.	13.4		62	S.E.
2,000.....	15.6		59	WSW.	9.7		69	S.E.
2,500.....	10.6	1.11	71	WSW.	5.6		79	S.E.
3,000.....	6.7		82	WSW.	5.3		93	S.S.E.
3,500.....	2.8	.78	98	W.	1.6	.62	93	S.S.E.

Wind observations by means of both kites and pilot balloons show that the occasional periods of high temperature over southern and eastern sections were accompanied by light free-air winds, particularly in the higher altitudes. This is well shown by the records at Groesbeck, where, with temperatures close to 100° F. on most days, the winds showed very few exceptions to a general condition of light air movement at all levels above about 2,000 meters. Also at Washington the warmest day (5th) was attended by light variable winds in the lower levels and easterly in the upper to about 10,000 meters. The inference from this, to the effect that the observed high temperatures were almost entirely the result of insolation heating the ground and lower air layers, uninterrupted by precipitation or invasions of cooler air from other sections, is confirmed by the kite observations at Broken Arrow on the 25th and 28th in the following table. These show the changes from one of the coolest days of the month, with a surface maximum temperature of 85° F. (29.4° C.) on the 25th, to the warmest day, with a surface maximum of 104° F. (40° C.) on the 28th. As the observations were not made at the same time of day on both dates, and the lower levels are therefore not strictly comparable, attention should be given principally to the temperatures above 1,000 meters, which show a gradually diminishing difference with altitude between the two dates until at 3,800 meters a reversal is noted, the temperature at that altitude being slightly lower on the 28th in a west wind than on the 25th in a north wind. By comparing the maximum surface temperature on the 28th, 40° , with the temperature at 3,800 meters, 2.7° , it is apparent that the heating in the lower levels that began on the 26th gradually extended to the upper levels until, at the time of maximum surface temperature on the 28th, a dry adiabatic lapse rate prevailed up to about 3,800 meters. This condition on the 28th evidently determined the high point of the warm period, because as the column of air having a dry adiabatic deepens it becomes increasingly difficult, owing to the rapid removal of the surface air by convection, for the surface temperature to rise further.

Altitude, m. s. l. (meters)	June 25, 1925		June 28, 1925	
	Tem- perature ($^{\circ}$ C.)	Wind direction	Tem- perature ($^{\circ}$ C.)	Wind direction
233 (surface).....	26.7	N.	28.8	SSW.
500.....	22.6	N.	27.8	SW.
1,000.....	17.7	N.	25.6	SW.
1,500.....	13.4	N.	22.3	SW.
2,000.....	11.0	N.	18.2	SW.
2,500.....	10.3	N.	13.7	WSW.
3,000.....	9.6	N.	9.2	WSW.
3,900.....	4.7	N.	2.7	W.

As usual for the time of year, winds of pronounced easterly component became increasingly frequent at most southern stations as the month advanced, so that Key West and San Juan showed resultant winds nearly due east at practically all levels, and Groesbeck south-east winds at the ground gradually backing with altitude to nearly east at 4,000 meters and above.

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during June, 1925

THE WEATHER ELEMENTS

By P. C. DAY, In Charge of Division

TEMPERATURE (° C.)

Altitude, m. s. l. (meters)	Broken Arrow, Okla. (233 m.)		Drexel, Nebr. (396 m.)		Due West, S. C. (217 m.)		Ellendale, N. Dak. (444 m.)		Groesbeck, Tex. (141 m.)		Royal Center, Ind. (225 m.)	
	Mean	De- parture from 7-yr. mean	Mean	De- parture from 10-yr. mean	Mean	De- parture from 5-yr. mean	Mean	De- parture from 8-yr. mean	Mean	De- parture from 7-yr. mean	Mean	De- parture from 7-yr. mean
Surface	27.9	+2.6	22.2	+0.7	28.7	+1.8	17.6	-1.6	28.1	+2.0	23.9	+0.6
250	27.7	+2.6	22.2	+0.7	28.2	+1.7	17.6	-1.6	26.9	+1.8	23.5	+0.5
500	25.6	+2.4	21.3	+0.5	25.2	+1.4	17.1	-1.8	24.4	+1.3	20.4	+0.1
750	24.0	+2.4	20.0	+0.7	23.3	+1.4	15.5	-1.8	22.7	+1.1	18.5	+0.2
1,000	22.3	+2.0	18.6	+0.6	21.5	+1.2	14.1	-1.8	21.2	+0.8	16.7	0.0
1,250	20.5	+1.5	17.4	+0.7	19.6	+1.0	12.8	-1.8	19.9	+0.7	14.9	-0.2
1,500	19.1	+1.5	16.1	+0.7	17.7	+0.9	11.8	-1.5	18.5	+0.5	13.5	-0.2
2,000	16.3	+1.6	13.8	+1.1	14.0	+0.6	9.5	-1.0	16.8	+1.1	10.4	-0.6
2,500	13.4	+1.5	10.9	+1.2	10.7	+0.6	6.9	-0.8	14.8	+1.6	7.1	-1.1
3,000	10.4	+1.6	8.0	+1.3	6.8	-0.3	4.4	-0.5	12.3	+1.7	3.7	-1.7
3,500	7.3	+1.7	4.8	+1.3	3.4	-0.6	1.5	-0.5	10.1	+2.1	1.1	-1.6
4,000	4.1	+1.6	2.0	+1.7	-----	-----	-1.2	-0.4	7.9	+2.6	-----	-----
4,500	1.2	+1.7	-0.8	+1.8	-----	-----	-3.5	+0.4	5.1	+2.8	-----	-----
5,000	-1.8	+1.4	-3.8	+1.9	-----	-----	-----	-----	2.4	+3.6	-----	-----

RELATIVE HUMIDITY (per cent)

Surface	57	-14	68	-2	54	-7	74	+3	64	-9	62	-2
250	57	-14	68	-2	54	-7	74	+3	64	-9	62	-2
500	59	-13	68	0	56	-7	73	+3	73	-3	64	-1
750	61	-11	64	-1	58	-6	69	+1	74	-1	65	+1
1,000	63	-8	63	-1	61	-4	68	+1	71	0	66	+1
1,250	66	-4	62	-1	64	-2	67	+1	68	+1	66	0
1,500	64	-4	61	0	67	0	63	-1	67	+4	64	-1
2,000	57	-6	57	-1	69	0	61	-1	53	-2	69	+7
2,500	52	-5	57	+1	64	-4	60	+1	44	-7	67	+14
3,000	49	-4	50	-4	70	+4	57	+2	40	-7	71	+21
3,500	47	-5	50	-3	74	+10	54	+3	29	-15	48	+5
4,000	49	-1	50	-2	-----	-----	54	+7	25	-18	-----	-----
4,500	48	+1	51	+1	-----	-----	40	-6	24	-22	-----	-----
5,000	-----	-----	51	-1	-----	-----	-----	-----	23	-23	-----	-----

VAPOR PRESSURE (md.)

Surface	21.34	-1.56	18.28	+0.31	20.69	-0.88	15.17	-1.02	23.69	-0.76	18.25	-0.18
250	21.18	-1.52	18.28	+0.31	20.19	-0.72	15.17	-1.02	23.31	-0.27	17.78	-0.35
500	19.59	-0.77	17.29	+0.43	17.53	-1.02	14.58	-1.10	21.96	+0.33	14.97	-0.76
750	18.06	-0.32	15.07	+0.37	16.20	-0.70	12.45	-1.26	20.18	+0.67	13.71	-0.64
1,000	16.88	-0.20	13.64	+0.28	15.09	-0.44	11.14	-1.20	17.71	+0.64	12.85	-0.36
1,250	15.67	-0.78	12.47	+0.36	14.15	-0.12	10.09	-1.03	15.78	+0.76	11.83	-0.29
1,500	13.97	-0.78	11.45	+0.65	13.30	+0.26	8.84	-1.03	14.35	+1.24	10.58	-0.27
2,000	10.57	-0.43	9.08	+0.44	11.05	+0.32	7.35	-0.62	10.30	+0.33	9.51	+1.07
2,500	7.98	-0.51	7.55	+0.64	8.30	-0.18	6.17	-0.28	7.71	-0.18	7.48	+1.72
3,000	6.14	-0.56	5.46	-0.09	6.72	+0.15	5.07	-0.13	6.20	-0.12	5.64	+1.50
3,500	4.94	-0.52	4.21	-0.22	5.22	+0.18	3.94	+0.01	4.36	-0.75	3.06	+0.47
4,000	4.04	-0.56	3.55	-0.03	-----	-----	3.21	0.00	3.78	-0.52	-----	-----
4,500	3.76	-0.98	3.00	+0.20	-----	-----	1.91	-0.64	3.53	-0.29	-----	-----
5,000	-----	-----	2.54	+0.18	-----	-----	-----	-----	3.35	-0.03	-----	-----

TABLE 2.—Free-air resultant winds (m. p. s.) during June, 1925

Altitude, m. s. l. (meters)	Broken Arrow, Okla. (233 meters)				Drexel, Nebr. (396 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)			
	Mean		7-year mean		Mean		10-year mean		Mean		5-year mean		Mean		8-year mean		Mean		7-year mean		Mean		7-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 7°W	7.4	S. 4°W	4.4	S. 2°E	3.0	S.	0.1	S. 51°W	2.4	S. 75°W	1.1	N. 47°W	1.6	S. 30°W	0.1	S. 2°W	4.7	S. 5°E	3.4	S. 55°W	2.2	S. 54°W	1.4
250	S. 8°W	7.4	S. 5°W	4.5	S. 2°E	3.6	S. 2°E	2.3	S. 49°W	2.2	S. 76°W	1.2	N. 61°W	1.3	S. 31°W	0.1	S. 3°W	5.1	S. 4°E	4.0	S. 37°W	2.4	S. 48°W	1.5
500	S. 13°W	8.6	S. 10°W	5.8	S. 2°E	3.6	S. 2°E	2.3	S. 45°W	2.8	S. 77°W	1.9	N. 61°W	1.3	S. 31°W	0.1	S. 7°W	5.9	S. 1°W	5.4	S. 49°W	4.5	S. 48°W	2.6
750	S. 17°W	8.8	S. 14°W	6.5	S. 13°W	5.2	S. 10°W	3.5	S. 65°W	3.0	S. 74°W	2.5	N. 85°W	1.2	S. 12°W	0.9	S. 6°W	6.3	S. 4°W	5.8	S. 49°W	6.2	S. 53°W	3.5
1,000	S. 21°W	8.6	S. 20°W	6.6	S. 19°W	6.1	S. 24°W	4.0	S. 79°W	3.1	S. 78°W	2.5	N. 78°W	1.7	S. 26°W	1.3	S. 3°W	6.6	S. 8°W	6.2	S. 58°W	7.5	S. 67°W	4.3
1,250	S. 27°W	8.7	S. 26°W	6.7	S. 26°W	6.9	S. 34°W	4.3	S. 89°W	3.1	S. 82°W	3.0	N. 85°W	2.3	S. 49°W	2.0	S. 4°W	6.7	S. 9°W	6.5	S. 59°W	8.9	S. 72°W	4.9
1,500	S. 27°W	8.8	S. 30°W	6.8	S. 37°W	7.2	S. 45°W	4.8	W.	3.7	S. 86°W	3.8	W.	3.0	S. 54°W	2.4	S. 4°W	6.8	S. 10°W	6.0	S. 70°W	6.0	S. 82°W	4.8
2,000	S. 25°W	8.2	S. 35°W	6.9	S. 49°W	9.7	S. 57°W	6.1	S. 81°W	4.4	S. 88°W	5.7	N. 89°W	4.5	S. 65°W	3.6	S. 6°W	6.6	S. 12°W	5.6	S. 79°W	10.5	S. 82°W	7.5
2,500	S. 20°W	8.1	S. 36°W	6.7	S. 60°W	9.9	S. 70°W	7.5	S. 72°W	3.8	S. 87°W	5.8	S. 71°W	5.9	S. 71°W	5.4	S. 1°W	6.2	S. 14°W	5.6	S. 69°W	12.2	S. 80°W	9.1
3,000	S. 28°W	7.5	S. 37°W	6.5	S. 73°W	10.5	S. 76°W	8.9	S. 80°W	8.2	S. 88°W	7.9	S. 71°W	8.2	S. 78°W	7.5	S. 4°W	5.8	S. 16°W	5.6	S. 67°W	11.5	S. 82°W	10.4
3,500	S. 42°W	5.1	S. 44°W	6.7	N. 84°W	12.6	S. 81°W	9.5	S. 85°W	11.7	S. 83°W	9.0	S. 81°W	10.1	S. 80°W	9.3	S. 5°E	6.6	S. 9°W	5.8	S. 37°W	8.7	S. 84°W	11.1
4,000	S. 85°W	6.2	S. 60°W	7.1	N. 86°W	10.7	N. 85°W	9.0	-----	-----	-----	-----	S. 78°W	13.2	S. 88°W	11.6	S. 23°E	7.0	S. 8°W	6.4	-----	-----	-----	-----
4,500	N. 72°W	8.6	S. 88°W	8.0	S. 78°W	12.4	N. 79°W	9.0	-----	-----	-----	-----	S. 62°W	15.1	N. 88°W	12.7	S. 45°E	10.1	S. 12°E	8.2	-----	-----	-----	-----
5,000	W.	13.0	N. 73°W	12.4	N. 84°W	12.3	N. 58°W	16.1	-----	-----	-----	-----	S. 45°W	16.0	N. 74°W	14.6	S. 67°E	10.0	S.	3.8	-----	-----	-----	-----

The atmospheric circulation during the month, as disclosed by the chart of average sea-level pressure, assumed the usual summer type in the main—high pressure over the Southeastern States, moderately low values over the interior, and again high pressure along the Pacific coast. These conditions were accentuated, however, in each locality as compared with normal conditions; and notably the southeastern high was maintained with unusual strength and persistence during the first decade, resulting in an unusually long period of southerly winds, high temperatures, and lack of precipitation over the eastern third of the country. At the same time pressure was distinctly lower than normal over the central and southern Rocky Mountain and Plateau regions and thence northeastward to the Great Lakes. Numerous cyclones, usually of small proportions, however, formed over the Southwest, and unable to overcome the anticyclonic area overlying the Southeastern States, moved toward the upper lakes, bringing an usually large number of rainy days to the Missouri and upper Mississippi Valley districts, and much cool, cloudy weather throughout the Northwest.

The early part of the month likewise had generally low pressure over the Pacific Coast States, and cool, cloudy weather resulted, with usually more than the average precipitation in the far Northwest and in portions of California.

During the last half of the month pressure conditions were largely reversed. Anticyclones became more numerous over the far Northwest, temperatures increased, and a period of unusually dry atmospheric conditions prevailed. Low pressure was still more or less persistent along the Canadian border, and rather frequent showers continued in the Northern States east of the Rocky Mountains. At the same time the atmospheric circulation over the Southeastern States became less stable, weather changes were more frequent, with a decided tendency to moderate temperatures, and local showers relieved to some extent the need for moisture.

The high pressure over the Southeastern States during the early part of the month favored persistent southerly